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groundwaters into the crust of the earth is appreciated; when the great restrictions upon their actual amount which have been demonstrated in recent years are grasped in their full significance; and when the great depths to which many veins extend are kept before us; we may justifiably state, as on page 24: "However important these (*i. e.*, magmatic waters) may be in the formation of certain kinds of ore deposits, they are insignificant in quantity compared to the great circulation of atmospheric water." It sometimes seems to the reviewer that even while stating newer facts almost from force of habit we are inclined to reiterate older doctrines from beneath which the newer facts have largely removed the foundations. Had we known at the outset of the limited vertical distribution of the meteoric groundwaters and of their small amount, it is quite possible that we should have had a less firmly rooted faith in them as the *prima facie* source of deep-seated circulations, and would have given other kinds of water greater relative importance. The subject is, however, young, and a gradual modification of views may come in time as we escape the hypnotic influence of the past. Indeed, as we read Professor Lindgren's subsequent pages, and especially Chapter VI., we feel as if, when the actual phenomena were reviewed, the magmatic waters seemed of greater and greater importance. Indeed, who can affirm that the surface waters were not themselves once magmatic?

The introductory portion also contains valuable chapters on faults, folds, openings in rocks, textures of deposits and ore-shoots, on almost all of which Professor Lindgren has previously written in a most illuminating way. The classification of mineral deposits, which is to form the framework of the later pages, is introduced by a condensed review of other schemes and of agents.

The scheme of classification is the foundation of the treatise. It is fundamentally based on mechanical processes of concentration on the one side, and chemical, on the other. While these two have been emphasized in one way and another by earlier writers, no one else has

so logically and completely carried out the chemical processes in determining the subgroups on the basis of temperature and pressure. The types of mineral deposits are, therefore, taken up in order, beginning with reactions at the surface at ordinary temperatures and pressures, passing to those in the rocks at greater and greater depths and terminating in the natural climax of those produced by processes of differentiation in magmas. Perhaps the question will arise in the minds of some, as to whether we are sufficiently well-informed regarding the temperatures and pressures at which minerals develop in order to make this grouping sound. The reply may be made, that the associations of minerals in the various types are in contrast; that we have learned much from their artificial production; and that the peculiar etch-figures afforded by quartz, a mineral of wide occurrence, and differing according to its crystallization above or below its conversion point of 575° C., have all given critical data now of great significance.

Professor Lindgren reviews practically all the famous mining districts of the world and in connection with them discusses with fullness and illuminating insight the questions of secondary enrichment, of persistence of mineral characters with depth, of contact zones, of magmatic segregations and of pegmatites. Indeed, no student of the subject can read these pages without feeling his interest quickened and his grasp of the causes which have led to the formation of mineral deposits greatly broadened. Professor Lindgren has, therefore, as stated in the opening sentence of this review, placed his colleagues and students everywhere under a great debt by the preparation of a masterly work.

J. F. KEMP

Der Mensch der Vorzeit. Von DR. HUGO OBERMAIER, Professor am internationalen "Institut de Paléontologie Humain," Paris. Mit 39 Tafeln, 12 Karten und 395 Textabbildungen. Allgemeiner Verlags-gesellschaft, M. B. H., Berlin, München, Wien. 1912.

"Der Mensch der Vorzeit" very appropriately constitutes Volume I of a monumental work in three volumes¹ entitled "Der Mensch aller Zeiten Natur und Kultur der Völker der Erde."

By way of introduction the author gives a résumé of ancient cosmogony and archeology as seen through medieval eyes, and the founding of geology, paleontology and prehistoric archeology as exact sciences.

The key to the Glacial period is found in the existing glaciers, which still cover about 10 per cent. of the land surface of the earth. The author is particularly well qualified to treat of the geology of the Ice Age as he has made a special study of the glacial phenomena in the French Pyrenees, where he found a succession of four terraces in the Garonne and Ariège valleys precisely as had been noted previously by Penck and Brückner in the foothills of the Alps. These he refers to the four glacial epochs for which he accepts Penck's terminology, beginning with the oldest: Günz, Mindel, Riss and Würm. In the Garonne valley the Günz terrace is 150 meters above the present stream bed; while the Mindel, Riss and Würm terraces are 100, 55 and 15 meters respectively above the present stream.

The great loess mantel stretching from southern England, Belgium and northern France across Germany to the Carpathian Mountains, Obermaier considers an eolian formation. His conclusion is based on the position, structure and content of the loess. In the Riesengebirge it reaches an elevation of 400 meters above the sea; the lines of stratification are not such as would be formed in water; and the animal remains found in the loess are for the most part land shells, freshwater shells being rare and fishes entirely wanting.

While the great loess mantel is evidently eolian, there are restricted loess deposits connected with valley terraces that owe their formation to the agency of water. The loess of

western and central Europe is exclusively of Quaternary age, but must be considered as having been deposited at various epochs. The author believes the latest loess to be post-glacial, while Penck would place it as far back as the maximum extension of the Würm glaciation.

The possible causes of the Ice Age may be classed as astronomical, geological and physical. The basis for the astronomical theories is that the movement of the earth is influenced not only by the sun, but also by the planets; the latter, although much smaller than the sun, are nevertheless able to bring about periodic changes in the form of the earth's orbit and the inclination of the earth's axis to the ecliptic. The precision of the equinoxes should also be considered. No one of the periodic changes in the movement of the earth is sufficient in itself to bring about a succession of glacial and interglacial epochs.

From the viewpoint of geology the legends concerning the lost Atlantis, or those pointing to a possible bridge across the north Atlantic, must ever remain purely legends. Does the theory of Kreichgauer furnish a key to the Ice Age? The author thinks favorably of it. Kreichgauer supposes the earth's axis to remain fixed and the earth's crust to move slowly on the molten mass within. Thus a spot on the equator might in the course of time find itself over one of the poles. Paleontology and the distribution of glacial phenomena are thought to offer evidences in support of this hypothesis.

As possible physical causes there may be cited changes in the character of the atmosphere, rendering it less penetrable by the sun's rays. According to Svante Arrhenius, a period of high percentage of carbonic acid in the air would be a period of cold, and *vice versa*. Periods of great volcanic activity would thus correspond to periods of cold; and the Quaternary volcanoes of Auvergne and the Rhine are known to have been active during a cold period. Of all the theories, the author gives preference to Kreichgauer's. Whether the glacial epochs were synchronous in the northern and southern hemispheres he is un-

¹ The authors of the other volumes are Ferdinand Birkner, Wilhelm Schmidt, Ferdinand Hestermann and Theodor Stratmann.

able to say categorically. That there were four glacial epochs alternating with interglacial epochs is reflected in the changing character of the animal and plant world. The association of animal and plant remains with human skeletal remains, and especially artifacts, often serves to throw light on the age of the latter.

The author divides the lower paleolithic into early Chellean, Chellean, Acheulian and Mousterian, describing in detail not only the well-known type specimens, but also various small forms only recently recognized as belonging to the earlier horizons. Many important stations are described at length; and ample space is given to the geographic distribution of the successive cultures.

The author traces diluvial man over practically the whole earth. He sifts the evidence bearing on the presence of diluvial man in countries outside of Europe, finding indications of a Chelleo-Mousterian industry widespread over both hemispheres. He believes it to be diluvial, but not necessarily everywhere of the same age.

The types characterizing the various upper paleolithic industries are fully described and figured: Aurignacian, Solutrean and Magdalenian, each with its subdivisions. The use of the Magdalenian *bâton de commandement* remains problematic. Of the many theories advanced as to the purpose it served, Obermaier favors Reinach's supposition that they might have been magic wands, rather than clubs, halter pieces, tent fixtures, figuræ, hunting trophies or sceptors. Of the Azilian epoch, transition epoch from the paleolithic to the neolithic, the fauna is neolithic, but the culture is still paleolithic. Breuil's conclusions as to the sequence in the development of paleolithic parietal art are accepted. Quaternary art in Europe is analogous to the art of modern primitive man, but not to that of neolithic man in Europe.

The popular interest in a definite chronology for man's antiquity is perennial. Authorities still differ enough in their estimates to admit of being grouped into three classes; radicals, conservatives and a middle class.

The author would place the Magdalenian, not during the Achen retreat, nor after the Bühl stage, but during the latter because of the reindeer fauna. In that respect he and Penck are practically in accord, although Penck believes the Magdalenians were living somewhere also during the maximum Würm cold as well as during the Achen stage. By giving to the Magdalenians more latitude in point of time, Penck finds it convenient to push back the Mousterian epoch much further than Obermaier would have it go. Both believe that the Mousterians passed through a cold and a warm stage. Penck allows for this by placing the early Mousterians in the Riss glacial epoch and the later Mousterians in the first half of the succeeding Riss-Würm interglacial, and the upper Mousterian with the first advance and maximum of the Würm glaciation. Penck would have the Chellean and Acheulian correspond to the second interglacial epoch. Both agree in assigning the human lower jaw of Mauer to the Mindel-Riss interglacial epoch; the Mauer specimen thus represents for Penck Chellean man or pre-Chellean and for Obermaier pre-paleolithic man.

The difficulty of substituting an absolute for a relative chronology is at once evident to any one familiar with the character of the phenomena to be dealt with. The advance and retreat of glaciers has been studied in recent times. The rate of deposition and erosion within certain limits is subject to measurement. For a continental ice sheet to form and push its way out of the north until it reaches central Europe requires a long time; and it was not at once evicted from the outposts gained. Even after its maximum force was spent, it disputed stubbornly every inch of the territory on the retreat. This program with occasional halts and advances was repeated four times. The Würm glacial deposits look fresh in comparison to those of the Riss, for example, and still greater weathering is to be noted in the deposits left by the Mindel and Günz, respectively. The size of the Würm terminal moraine and the amount of material left as mantels on the retreat of

the ice, testify to the eroding and transporting power of the last glaciation, as well as to its long period of activity. The Riss terminal moraines and gravel beds are still greater; hence indicate a longer period of glaciation for the Riss epoch. If the various glacial epochs were of unlike duration, so also were the interglacial epochs. Penck finds that in the foothills of the Alps, where the gravel beds of the four glacial epochs appear as terraces, those of the first two epochs lie considerably higher than those of the last two. The valley erosion between the Mindel and the Riss epoch was, therefore, greater than that of the Riss-Würm interglacial epoch. On the other hand, the Riss-Würm is longer than the time that has elapsed since the maximum Würm extension. The alternation of cold and warm faunas confirms the theory of the relatively great length of time required. Since authorities do not agree as to the geological position of the various cultural epochs, it is not strange that they should also differ in their estimates concerning the absolute length of these epochs.

Obermaier admits that his own figures are ultra-conservative. He places the close of the neolithic age at about 2000 B.C., its beginning some 6000 B.C. The date separating the proto-neolithic from the Magdalenian is 12000 B.C., the beginning of the Magdalenian at least 16000 B.C. To the Solutrean and Aurignacian each he ascribes 5,000 years, and to the Mousterian, Acheulian and Chellean each 10,000 years. He thus arrives at a minimum figure of 50,000 years for the time that has elapsed since the appearance of paleolithic man, and at least 100,000 years for the age of the pre-paleolithic Heidelberg jaw.

L. Pilgrim is much more liberal in his estimates for a chronology of the Ice Age, his total amounting to 1,290,000 years. Penck's figures are somewhat more conservative; he allows some 30,000 years for the time that has elapsed since the maximum Würm glaciation, 60,000 years for the Riss-Würm epoch, more than 240,000 years for the Mindel-Riss epoch, and for the entire duration of the Ice Age 1,000,000 years. Hildebrandt's estimate for the

Quaternary is 530,000 years. Schlosser and Boule are inclined to regard the Günz epoch as belonging to the upper Pliocene.

Obermaier rightly rejects all human remains whose age is in doubt. After this is done there is still left a formidable list representing every culture horizon. The Tilbury skeleton is thought to be of Quaternary age, while the remains from Galley Hill, Engis, Furfooz, La Hastière, Trou Magrite, Goyet, Trou du Chaleux, Brûx and Podbaba, are set aside as uncertain. He believes that we must go back to Eocene times in order to find the bridge that connects man with the ancestors of living anthropoids and cites *Pithecanthropus erectus* as an example of how close an anthropoid line can come to the human without being or becoming a part of it. *Proplio-pithecus haeckeli*, a fossil ape from the Oligocene of Egypt, is probably the ancestor not only of Simiidae, but also of Hominidae.

The eolithic question is discussed at considerable length. It is contended that on mechanical grounds alone there is no way of distinguishing between man-made and nature-made eoliths. The so-called Tertiary and Quaternary eoliths are not accepted unless they are made of material foreign to the deposit in which they are found, or are associated with human bones, hearths or other indubitable evidence of man's presence. On the other hand, it is admitted that some primitive races of to-day are in the eolithic stage, that all eoliths may not be due to natural causes, and that the lower jaw from Mauer represents eolithic man.

In Part II. the reader has a handy résumé of the culture periods connecting the paleolithic with historic times; neolithic, bronze and iron ages. It is, however, in Part I. that the author speaks with special authority and from a wealth of first-hand knowledge. Professor Obermaier is to be congratulated on the completion of a work that will be admired alike for its magnitude and general excellence.

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